

THAT WHICH IS CLAIMED IS:

1. A radiation-curable adhesive composition comprising at least one tackifier resin and at least one radiation-curable composition wherein said tackifier resin comprises monomer repeating units from at least one aromatic monomer and at least one acrylate monomer; wherein said radiation-curable composition can be cured by exposure to radiation.
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- 10 2. A radiation-curable adhesive composition according to Claim 1 wherein said aromatic monomer is at least one selected from the group consisting of olefinic substituted aromatics.
- 15 3. A radiation-curable adhesive composition according to Claim 2 wherein said aromatic monomer is selected from the group consisting of styrene, alpha-methyl styrene, vinyl toluene, indene, methylindenones, divinylbenzene, dicyclopentadiene, and methyl-dicyclopentadiene.
- 20 4. A radiation-curable adhesive composition according to Claim 1 wherein said acrylate monomer has the general formula:



wherein R_1 is selected from the group consisting of hydrogen, aliphatic groups, and aromatic groups; wherein R_2 is selected from the group consisting of hydrogen, aliphatic groups, and aromatic groups; and wherein R_3 is selected from the group consisting of hydrogen, aliphatic groups, aromatic groups.
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5. A radiation-curable adhesive composition according to Claim 4
wherein said aliphatic group has 1 to about 20 carbon atoms.
6. A radiation-curable adhesive composition according to Claim 5
5 wherein said aliphatic group has 1 to 12 carbon atoms.
7. A radiation-curable adhesive composition according to Claim 5
wherein said aromatic group has about 6 to about 20 carbon atoms.
- 10 8. A radiation-curable adhesive composition according to Claim 5
wherein both R₁ and R₂ of the acrylate monomer is hydrogen.
9. A radiation-curable adhesive composition according to Claim 1
wherein said acrylate monomer is selected from the group consisting of
15 methyl acrylate, acrylic acid, methacrylic acid, methyl methacrylate, ethyl
acrylate, ethyl methacrylate, butyl acrylate, butyl methacrylate, isobutyl
acrylate, isobutyl methacrylate, n-hexyl acrylate, n-hexyl methacrylate,
ethylhexyl acrylate, ethylhexyl methacrylate, n-heptyl acrylate, n-heptyl
methacrylate, 2-methylheptyl (meth)acrylate, octyl acrylate, octyl
20 methacrylate, isoctyl (meth)acrylate, n-nonyl(meth)acrylate, iso-
nonyl(meth)acrylate, decyl(meth)acrylate, isodecyl acrylate, isodecyl
methacrylate, dodecyl(meth)acrylate, isobornyl(meth)acrylate, lauryl
methacrylate, lauryl acrylate, tridecyl acrylate, tridecyl methacrylate, stearyl
acrylate, stearyl methacrylate, glycidyl methacrylate, alkyl crotonates, vinyl
25 acetate, di-n-butyl maleate, di-octylmaleate, acetoacetoxyethyl
methacrylate, acetoacetoxyethyl acrylate, acetoacetoxypropyl methacrylate,
acetoacetoxypropyl acrylate, diacetone acrylamide, acrylamide,
methacrylamide, hydroxyethyl methacrylate, hydroxyethyl acrylate, allyl
methacrylate, tetrahydrofurfuryl methacrylate, tetrahydrofurfuryl acrylate,
30 cyclohexyl methacrylate, cyclohexyl acrylate, n-hexyl acrylate, n-hexyl

methacrylate, 2-ethoxyethyl acrylate, 2-ethoxyethyl methacrylate, isodecyl
methacrylate, isodecyl acrylate, 2-methoxy acrylate, 2-methoxy
methacrylate, 2-(2-ethoxyethoxy) ethylacrylate, 2-phenoxyethyl acrylate,
2-phenoxyethyl methacrylate, isobornyl acrylate, isobornyl methacrylate,
5 caprolactone acrylate, caprolactone methacrylate, polypropyleneglycol
monoacrylate, polypropyleneglycol monomethacrylate,
poyethyleneglycol(400) acrylate, polypropyleneglycol(400) methacrylate,
benzyl acrylate, benzyl methacrylate, sodium 1-allyloxy-2-hydroylpropyl
sulfonate, acrylonitrile, and mixtures thereof.

10 10. A radiation-curable adhesive composition according to Claim 1
wherein said acrylate monomer has up to about 20 carbon atoms.

15 11. A radiation-curable adhesive composition according to Claim 10
wherein said acrylate monomer is selected from the group consisting of
acrylic acid, 2-ethylhexyl acrylate, methyl methacrylate, methyl acrylate,
acrylic acid, methacrylic acid, methyl methacrylate, ethyl acrylate, ethyl
methacrylate, butyl acrylate, butyl methacrylate, isobutyl acrylate, isobutyl
methacrylate, n-hexyl acrylate, n-hexyl methacrylate, ethylhexyl acrylate,
20 ethylhexyl methacrylate, n-heptyl acrylate, n-heptyl methacrylate,
2-methylheptyl (meth)acrylate, octyl acrylate, octyl methacrylate, isoctyl
(meth)acrylate, n-nonyl(meth)acrylate, iso-nonyl(meth)acrylate,
decyl(meth)acrylate, isodecyl acrylate, isodecyl methacrylate,
dodecyl(meth)acrylate, isobornyl(meth)acrylate, hydroxyethyl methacrylate,
25 hydroxyethyl acrylate, allyl methacrylate, cyclohexyl methacrylate,
cyclohexyl acrylate, n-hexyl acrylate, n-hexyl methacrylate, isobornyl
acrylate, isobornyl methacrylate, and mixtures thereof.

30 12. A radiation-curable adhesive composition according to Claim 11
wherein said acrylate monomer is acrylic acid and 2-ethylhexyl acrylate.

13. A radiation-curable adhesive composition according to Claim 1 wherein said acrylate monomer contains at least one functional group selected from the group consisting of hydroxy, cycloaliphatic, acid, epoxide, amide, acrylonitril and acrylate groups.

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14. A radiation-curable adhesive composition according to Claim 1 wherein said tackifier resin is produced by a radical catalyzed polymerization process utilizing at least one initiator.

10 15. A radiation-curable adhesive composition according to Claim 14 wherein said initiator is selected from the group consisting of diacyl peroxides, dialkylperoxidicarbonates, tert-alkyl peroxyesters, di-tert-alkyl peroxides, tert-alkyl hydroperoxides, ketone peroxides, and mixtures thereof.

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16. A radiation-curable adhesive composition according to Claim 1 wherein said tackifier resin has a low residual monomer concentration.

17. A radiation-curable adhesive composition according to Claim 16

20 wherein said tackifier resin is produced by a process comprising contacting a tackifier resin product stream with at least one carrier at a temperature sufficient to remove a portion of the residual monomers to produce the tackifier resin having a low residual monomer concentration.

25 18. A radiation-curable adhesive composition according to Claim 16 wherein said tackifier resin having a low residual monomer concentration does not significantly decrease the moisture vapor transport rate of said radiation-curable adhesive composition.

19. A radiation-curable adhesive composition according to Claim 18
wherein said tackifier resin does not decrease the moisture vapor transport
rate of said radiation-curable adhesive composition by more than 25%.

5 20. A radiation-curable adhesive composition according to Claim 16
wherein the moisture vapor transport rate of said radiation-curable adhesive
composition is the same or increased over said radiation-curable
composition alone.

10 21. A radiation-curable adhesive composition according to Claim 16
wherein the moisture vapor transport rate of said radiation-curable adhesive
composition ranges from about 200 to about 3000.

15 22. A radiation-curable adhesive composition according to Claim 21
wherein the moisture vapor transport rate of said radiation-curable adhesive
composition ranges from about 500 to 1500.

20 23. A radication-curable adhesive composition according to Claim 16
wherein said residual monomer concentration of said tackifier resin is less
than about 600 ppm by weight based on the weight of said tackifier resin.

25 24. A radiation-curable adhesive composition according to Claim 23
wherein said residual monomer concentration of said tackifier resin is less
than about 300 ppm by weight based on the weight of said tackifier resin.

25 25. A radiation-curable adhesive composition according to Claim 16
wherein said residual monomer concentration of said tackifier resin is less
than about 200 ppm aromatic monomer based on the weight of said
tackifier resin and less than about 400 ppm acrylic monomer.

26. A radiation-curable adhesive composition according to Claim 25 wherein said residual monomer concentration of said tackifier resin is less than about 100 ppm by weight aromatic monomer and less than about 150 ppm by weight acrylic monomer.

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27. A radiation-curable adhesive composition according to Claim 16 wherein said tackifier resin having a low residual monomer concentration has a residual solvent level less than about 500 ppm by weight based on the weight of said tackifier resin.

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28. A radiation-curable adhesive composition according to Claim 1 wherein the amount of aromatic monomer repeating units in the tackifier resin ranges from about 20% to about 70% based on the total amount of monomer repeating units in the tackifier resin.

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29. A radiation-curable adhesive composition according to Claim 1 wherein the amount of acrylate monomer repeating units in said tackifier resin ranges from about 30% to about 80% based on the total amount of monomer repeating units in the tackifier resin.

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30. A radiation-curable adhesive composition according to Claim 1 wherein said tackifier resin has a R&B softening point ranging from being a liquid at room temperature to about 180°C.

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31. A radiation-curable adhesive composition according to Claim 1 wherein said acid number of said tackifier resin ranges from about 0 to about 300 mg KOH/g resin.

32. A radiation-curable adhesive composition according to Claim 1 wherein said hydroxyl number of said tackifier resin ranges from about 0 to about 300.

5 33. A radiation-curable adhesive composition according to Claim 1 wherein the MMAP cloud point of said tackifier resin is less than 50°C.

10 34. A radiation-curable adhesive composition according to Claim 1 wherein the number average molecular weight (Mn) of said tackifier resin ranges from about 1,500 to about 7,000 daltons.

15 35. A radiation-curable adhesive composition according to Claim 1 wherein the number average molecular weight (Mn) of said tackifier resin ranges from 2,000 to 4,000 daltons.

20 36. A radiation-curable adhesive composition according to Claim 1 wherein the weight average molecular weight (Mw) of the tackifier resin ranges from about 2,000 to about 25,000 daltons.

25 37. A radiation-curable adhesive composition according to Claim 1 wherein the weight average molecular weight (Mw) of the tackifier resin ranges from 3,000 to 10,000.

30 38. A radiation-curable adhesive composition according to Claim 1 wherein the z-average molecular weight (Mz) of said tackifier resin ranges from about 3,000 to about 75,000 daltons.

35 39. A radiation-curable adhesive composition according to Claim 1 wherein the z-average molecular weight (Mz) of said tackifier resin ranges from 5000 to 20000.

40. A radiation-curable adhesive composition according to Claim 1
wherein the Gardner color of said tackifier resin is less than 5.

41. A radiation-curable adhesive composition according to Claim 1
5 wherein said tackifier resin has an aromaticity of 45% or higher and an acid
number of 100 mg KOH/g resin or lower.

42 A radiation-curable adhesive composition according to Claim 1
wherein said tackifier resin has a softening point of 80°C or higher.
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43. A radiation-curable adhesive composition according to Claim 1
wherein said tackifier resin comprises repeating units from at least one
monomer selected from styrene, acrylic acid, and 2-ethylhexyl acrylate.

15 44. A radiation-curable adhesive composition according to Claim 43
wherein the amount of styrene repeating units ranges from 0 to 100%
based on the total amount of monomer repeating units in the tackifier resin.

20 45. A radiation-curable adhesive composition according to Claim 44
wherein the amount of acrylic acid and 2-ethylhexyl acrylate ranges from
0-100% based on the total amount of monomer repeating units in the
tackifier resin.

25 46. A radiation-curable adhesive composition according to claim 43
wherein the amount of styrene repeating units ranges from about 20% to
about 70% based on the total amount of monomer repeating units in said
tackifier resin, and the combined amount of acrylic acid repeating units and
2-ethylhexyl acrylate repeating units ranges from about 30% to about 80%.

47. A radiation-curable adhesive composition according to Claim 1 wherein said radiation-curable composition is at least one selected from the group consisting of acrylic compositions, epoxides, urethanes, hybrid compositions, isoprene compositions, and styrene block copolymers.

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48. A radiation-curable adhesive composition according to Claim 47 wherein said acrylic compositions are selected from acrylic monomers, acrylic oligomers, and acrylic polymers.

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49. A radiation-curable adhesive composition according to Claim 48 wherein said acrylic monomer is at least one selected from the group consisting of acrylic acid, 2-ethylhexyl acrylate, methyl methacrylate, methyl acrylate, acrylic acid, methacrylic acid, methyl methacrylate, ethyl acrylate, ethyl methacrylate, butyl acrylate, butyl methacrylate, isobutyl acrylate, isobutyl methacrylate, n-hexyl acrylate, n-hexyl methacrylate, ethylhexyl acrylate, ethylhexyl methacrylate, n-heptyl acrylate, n-heptyl methacrylate, 2-methylheptyl (meth)acrylate, octyl acrylate, octyl methacrylate, isoctyl (meth)acrylate, n-nonyl(meth)acrylate, iso-nonyl(meth)acrylate, decyl(meth)acrylate, isodecyl acrylate, isodecyl methacrylate, dodecyl(meth)acrylate, isobornyl(meth)acrylate, hydroxyethyl methacrylate, hydroxyethyl acrylate, allyl methacrylate, cyclohexyl methacrylate, cyclohexyl acrylate, n-hexyl acrylate, n-hexyl methacrylate, isobornyl acrylate, isobornyl methacrylate, and mixtures thereof.

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50. A radiation-curable adhesive composition according to Claim 48 wherein said acrylic oligomers comprise at least one repeating unit selected from the group consisting of acrylic acid, 2-ethylhexyl acrylate, methyl methacrylate, methyl acrylate, acrylic acid, methacrylic acid, methyl methacrylate, ethyl acrylate, ethyl methacrylate, butyl acrylate, butyl methacrylate, isobutyl acrylate, isobutyl methacrylate, n-hexyl acrylate,

n-hexyl methacrylate, ethylhexyl acrylate, ethylhexyl methacrylate, n-heptyl acrylate, n-heptyl methacrylate, 2-methylheptyl (meth)acrylate, octyl acrylate, octyl methacrylate, isoctyl (meth)acrylate, n-nonyl(meth)acrylate, iso-nonyl(meth)acrylate, decyl(meth)acrylate, isodecyl acrylate, isodecyl 5 methacrylate, dodecyl(meth)acrylate, isobornyl(meth)acrylate, hydroxyethyl methacrylate, hydroxyethyl acrylate, allyl methacrylate, cyclohexyl methacrylate, cyclohexyl acrylate, n-hexyl acrylate, n-hexyl methacrylate, isobornyl acrylate, isobornyl methacrylate, and mixtures thereof.

10 51. A radiation-curable adhesive composition according to Claim 48 wherein said acrylic polymers include both homopolymers, copolymers, and terpolymers produced from at least one monomer selected from the group consisting of methyl acrylate, acrylic acid, methacrylic acid, methyl methacrylate, ethyl acrylate, ethyl methacrylate, butyl acrylate, butyl 15 methacrylate, isobutyl acrylate, isobutyl methacrylate, n-hexyl acrylate, n-hexyl methacrylate, ethylhexyl acrylate, ethylhexyl methacrylate, n-heptyl acrylate, n-heptyl methacrylate, 2-methylheptyl (meth)acrylate, octyl acrylate, octyl methacrylate, isoctyl (meth)acrylate, n-nonyl(meth)acrylate, iso-nonyl(meth)acrylate, decyl(meth)acrylate, isodecyl acrylate, isodecyl 20 methacrylate, dodecyl(meth)acrylate, isobornyl(meth)acrylate, lauryl methacrylate, lauryl acrylate, tridecyl acrylate, tridecyl methacrylate, stearyl acrylate, stearyl methacrylate, glycidyl methacrylate, alkyl crotonates, vinyl acetate, di-n-butyl maleate, di-octylmaleate, acetoacetoxymethyl methacrylate, acetoacetoxymethyl acrylate, acetoacetoxymethyl methacrylate, 25 acetoacetoxymethyl acrylate, diacetone acrylamide, acrylamide, methacrylamide, hydroxyethyl methacrylate, hydroxyethyl acrylate, allyl methacrylate, tetrahydrofurfuryl methacrylate, tetrahydrofurfuryl acrylate, cyclohexyl methacrylate, cyclohexyl acrylate, n-hexyl acrylate, n-hexyl 30 methacrylate, 2-ethoxyethyl acrylate, 2-ethoxyethyl methacrylate, isodecyl methacrylate, isodecyl acrylate, 2-methoxy acrylate, 2-methoxy

methacrylate, 2-(2-ethoxyethoxy) ethylacrylate, 2-phenoxyethyl acrylate, 2-phenoxyethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, caprolactone acrylate, caprolactone methacrylate, polypropyleneglycol monoacrylate, polypropyleneglycol monomethacrylate,

5 poyethyleneglycol(400) acrylate, polypropyleneglycol(400) methacrylate, benzyl acrylate, benzyl methacrylate, sodium 1-allyloxy-2-hydroylpropyl sulfonate, acrylonitrile, and mixtures thereof.

10 52. A radiation-curable adhesive composition according to Claim 48 wherein said acrylic polymers comprise repeating units from acrylic monomers and at least one polar copolymerizable monomers.

15 53. A radiation-curable adhesive composition according to Claim 52 wherein said polar copolymerizable monomer is at least one selected from the group consisting of cyanoalkyl acrylates, acrylamides, substituted acrylamides, N-vinyl pyrrolidone, N-vinyl caprolactam, acrylonitrile, vinyl chloride, vinylidene chloride, diallyl phthalate, and mixtures thereof.

20 54. A radiation-curable adhesive composition according to Claim 1 wherein said radiation-curable acrylic polymers are selected from the group consisting of acrylic copolymers, acrylated polyethers, acrylated polyester-based polyurethanes, methacrylated polyesters, and acrylated epoxies.

25 55. A radiation-curable adhesive composition according to Claim 54 wherein said radiation-curable acrylic polymer is a ultraviolet light reactive, solvent free acrylic copolymer with a Tg of less than or equal to about – 32°C or lower and a viscosity of less than or equal to about 24000 mPa.s at 120°C.

56. A radiation-curable adhesive composition according to Claim 1
wherein the amounts of said tackifier resin ranges from about 0.1% to about
50% based on the weight of the radiation-curable adhesive composition.

- 5 57. A radiation-curable adhesive composition according to Claim 56
wherein the amounts of tackifier resin ranges from 0.1% to 25% based on
the weight of the radiation-curable adhesive composition.

- 10 58. A radiation-curable adhesive composition according to Claim 1
further comprising at least one photo-initiator.

59. A radiation-curable adhesive composition according to Claim 1
further comprising at least one crosslinking agent.

- 15 60. A radiation-curable adhesive composition according to Claim 1
further comprising at least one additive selected the group consisting of
from reinforcing agents, fire retardants, foaming agents, conventional
tackifiers, plasticizers, oils, antioxidants, polymers, curable/reactive
monomers, crosslinking agents, fillers, and pigments.

- 20 61. A radiation-cured adhesive composition comprising at least one
tackifier resin, at least one radiation-curable composition, and at least one
substrate; wherein said tackifier resin comprises monomer repeating units
from at least one aromatic monomer and at least one acrylate monomer;
25 wherein said radiation-curable composition is exposed to radiation.

62. A radiation-cured adhesive composition according to Claim 61
wherein said radiation is selected from ultraviolet light, electron beam,
gamma ray, and X-ray.

63. A process of making a radiation-curable adhesive composition, said process comprising providing at least one tackifier resin and at least one radiation-curable composition wherein said tackifier resin comprises monomer repeating units from at least one aromatic monomer and at least 5 one acrylate monomer.

64. A process of making a radiation-cured adhesive composition said process comprises: 1) providing at least one tackifier resin and at least one radiation-curable composition to produce a radiation-curable adhesive 10 composition, 2) contacting said radiation-curable adhesive composition with at least one substrate, and 3) exposing said radiation-curable adhesive composition to radiation in an amount sufficient to produce said radiation-cured adhesive composition; wherein said tackifier resin comprises monomer repeating units from at least one aromatic monomer and at least 15 one acrylate monomer.

65. A process according to Claim 64 wherein said radiation is selected from ultraviolet light, electron beam, gamma ray, and X-ray radiation.

20 66. A process according to Claim 65 wherein said radiation is ultraviolet light having an effective ultraviolet wavelength ranging from about 100 nm to about 400 nm.

25 67. A process according to Claim 65 wherein said radiation is electron beam radiation in an amount ranging from about 1 megarads (Mrads) to about 30 Mrads.

30 68. A process according to Claim 64 wherein said substrate is selected from the group consisting of polyethylene terephthalate, biaxially oriented polypropylene, woven fabrics, non-woven fabrics, metals, metal foils,

paper, glass, ceramics, and composite materials comprising laminates of one or more of these materials.

69. A process to produce a UV-cured adhesive composition, said
5 process comprising: 1) contacting a styrene-acrylate tackifier resin and an acrylic copolymer to produce a UV-curable adhesive composition; wherein said styrene-acrylate tackifier comprises repeating units from styrene, acrylic acid and 2-ethylhexyl acrylate, 2) contacting the UV-curable adhesive composition with at least one substrate, and 3) exposing the
10 UV-curable adhesive composition to UV light having a wavelength in a range of about 220 nm to about 280 nm to produce said UV-cured adhesive composition.

70. A process to produce a radiation-cured adhesive composition, said
15 process comprising: 1) contacting at least one radiation-curable acrylic monomer or oligomer, at least one photo-initiator, and optionally a thixotropic agent to produce a mixture, 2) polymerizing said mixture to a viscosity sufficient to produce a coatable syrup, 3) mixing at least one tackifier resin with said coatable syrup to produce said radiation-curable adhesive composition, and 4) optionally, adding additional photo-initiator to said radiation-curable adhesive composition, 5) coating said radiation-curable onto at least one substrate to produce a coated substrate; and 6) exposing said coated substrate to radiation in an inert atmosphere.
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25 71. An article comprising said radiation-curable adhesive composition of
Claim 1.

72. An article comprising said radiation-cured adhesive composition of
Claim 61.